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External morphology of a species of *Metajapyx* (Diplura: Japygidae) from Washington[1]

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Abstract.—Scanning electron microscopy was used to aid in describing the external morphology of a species of *Metajapyx* collected in 1986 from southeastern Washington State. Specimens had extremely setaceous, 26 segmented antennae with trichobothria present on segments 4 and 5. Forcep-like cerci were armed with toothlike projections on the inner surface. Genital papillae were observed on the 8th abdominal sternum of a single specimen. Setose subcoxal organs were visible between the 1st and 2nd abdominal sterna. The mouth parts had several unusual modifications. The mandibles were elongate and toothed. The maxillae were composed of 3 segmented palps, lacinia with a strongly curved, sclerotized entire lamina, and 5 pectinate inner laminae; the galea was reduced. The mouth parts are probably specialized for feeding on soil micro-flora and fauna and for grooming the antennae and body surface.

Introduction

Few North American insects are as poorly known as those in the order Diplura. Diplurans have been found under stones, in dead wood, among fallen leaves, and in soil (Paelt 1957).

As of 1941 the family Japygidae was represented by less than a dozen species from the United States (Fox 1941). To date most studies on the family Japygidae have been either taxonomic descriptions or collecting records (Silvestri 1947, Young 1951, Chandler 1957, Smith and Bolton 1964). An extensive review of dipluran morphology can be found in Denis and Bitsch (1973) and Matsuda (1979), with frequent reference to the genera *Campodea* and *Japyx*. There are no records of specimens of the genus *Metajapyx* ever having been collected from the Pacific Northwest. Little information on biology has been published.

The purpose of this paper is to present a morphological examination of a *Metajapyx* species, family Japygidae, common to southeastern Washington.

Materials and Methods

All examined *Metajapyx* specimens were collected 3.2 km north of Lower Granite Dam along the Snake River (Garfield Co.), Washington in loose soil (elevation 240 m). Collections were made on 23 January, 6 February, and 27 April 1986. Length of collected specimens from 23 January was 7.80 ± 0.01 mm (n = 20)[4].

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[4]Mean ± SE (N).

Ten specimens were examined with scanning electron microscopy (SEM) using an ETEC Autoscan U-1, and photographs were taken with 55 Polaroid P/N film. Live *Metajapyx* specimens were killed with ether or placed directly into boiling water, then preserved in 70% alcohol. Mouth parts were examined intact or dissected from the head prior to fixation. After rehydration for 24 hours, specimens were air-dried or fixed with 2% osmium tetroxide (OsO_4). Specimens were coated with gold (30 nm) using a Technics Hummer Sputter Coater.

Light microscopy was used to make morphometric measurements on *Metajapyx* specimens collected 6 February and preserved in 70% alcohol. Head width was measured from the base of the diverging frontal sutures, and head length was measured from between the antennal scapes to the base of the coronal suture (Figs. 1a-a and 1a-b). Mandibles dissected from specimens collected 6 February were mounted on microscope slides in Hoyer's solution. All measurements were made using either a Wild M 5A binocular microscope or an Olympus BH2 compound microscope connected to a Houston Highpad digitizer and Apple IIe microcomputer.

Laboratory observations of *Metajapyx* behavior were made to support interpretations of the functional morphology revealed by SEM. Specimens were obtained 21 February 1987, along the Snake River and kept in the laboratory at room temperature in 1 liter glass containers filled with loose soil.

Results and Discussion

Head and Antennae.—The head capsule of *Metajapyx* is without compound eyes or ocelli, and is rectangular. Epicranial and postoccipital sutures were visible on the dorsal surface. Head width was 732.14 ± 41.23 μm ($n = 8$), and head length was 683.03 ± 71.42 μm ($n = 8$). Antennae are filiform and 26 segmented with dense setae on segments 5 through 26 (Fig. 2). The numerous antennal setae are probably important in prey location, in orientation through the soil cavities, and in mating. Trichobothria (sensory setae) were visible on segments 4 and 5 (Fig. 2a). These structures originate from deeper pits than adjacent setae; only a single trichobothrium was located on each segment. Trichobothria in *Catajapyx aquilonaris* (Silvestri) occur on segments 4–6 and may function in orientation and reception of air currents (Nosek et al. 1974).

Mouth Parts.—Mouth parts are entognathous and reduced. The labium is subdivided into a pre- and postmentum, with postmentum clearly divided into a distal mentum and proximal submentum (Figs. 1b, 3, and 4). Labial palpi are 1-segmented, 3 times as long as wide, and have 10–11 setae (Fig. 3a). Admental plates (Silvestri 1933) are lateral to the prementum (Figs. 1b–b and 3b).

The maxillae have 3-segmented palps with approximately 16 setae/palp (Fig. 4a), flap-like, unsclerotized galeae (Figs. 4b and 5b), and highly modified laciniae (Figs. 4c, 5c, and 8). Mandibles are elongate and monocondylic (Figs. 6 and 7). Right mandible length was 609.27 ± 48.45 μm ($n = 2$); left mandible length was 625.77 ± 34.02 μm ($n = 2$). Twenty minutes of laboratory observations of *Metajapyx* specimens revealed that the mandibles can extend forward in front of the maxillae during feeding. The inner mandibular surface is concave (Fig. 6) and has a prominent dorsal tooth, while five apical teeth are apparent on the outer mandibular surface (Fig. 7). Careful dissection of the area around the mandibles revealed that they are retracted into the head dorsad to the maxillae. The laciniae are highly modified and

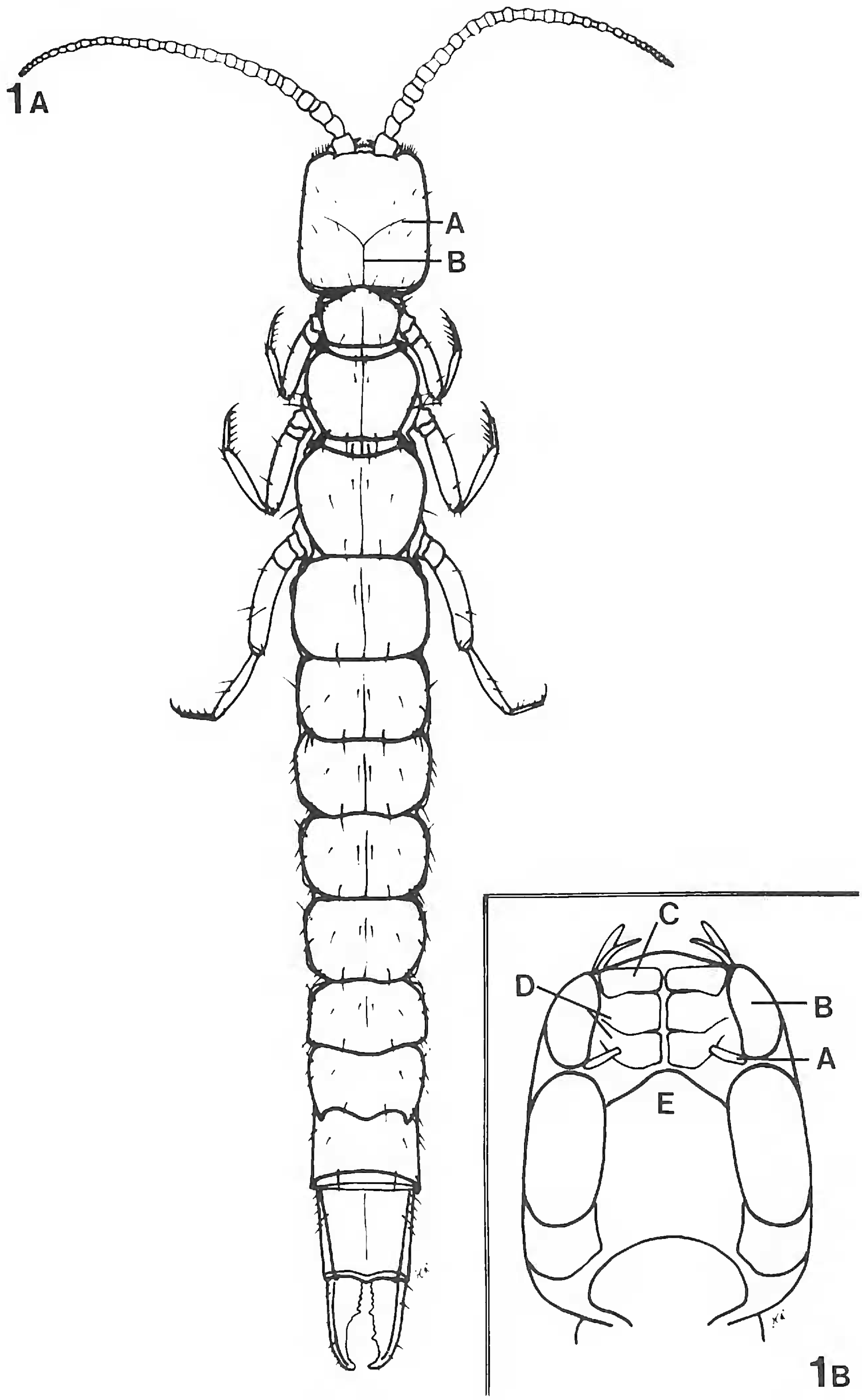
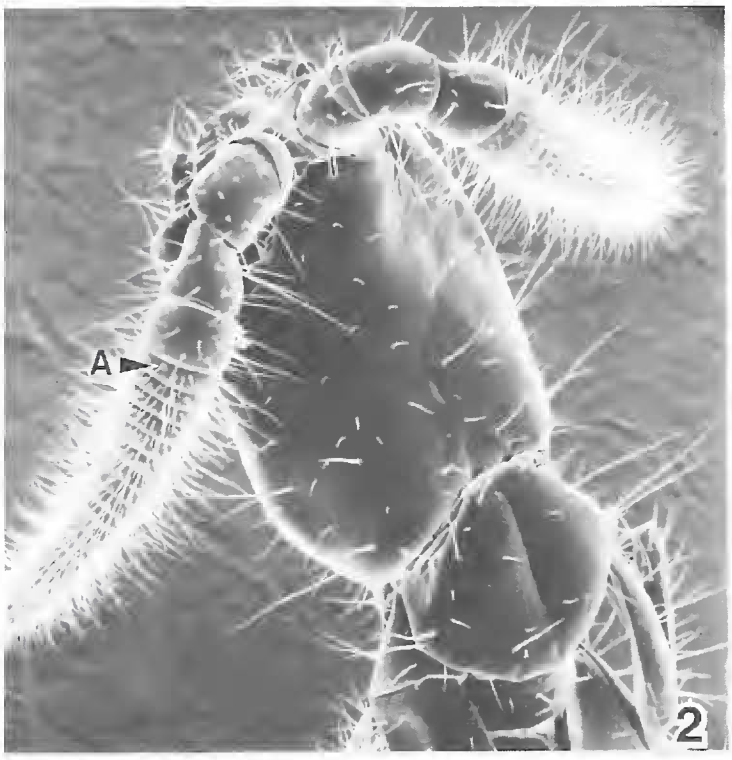
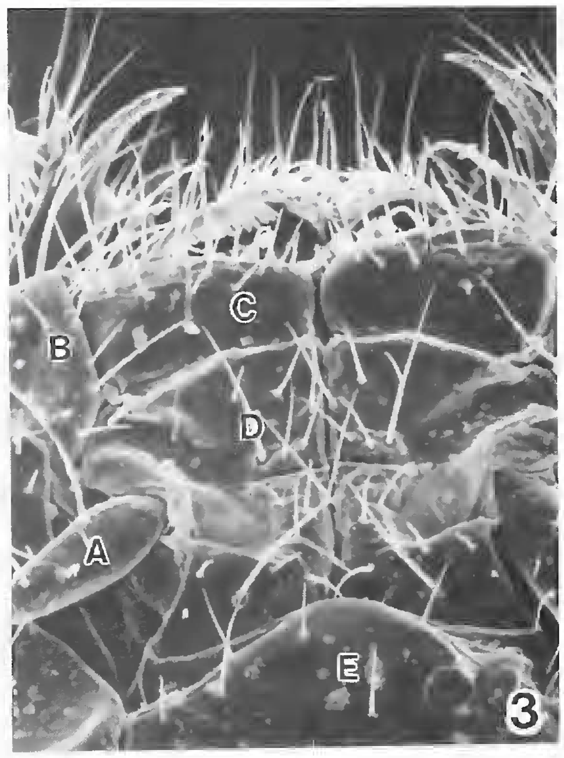
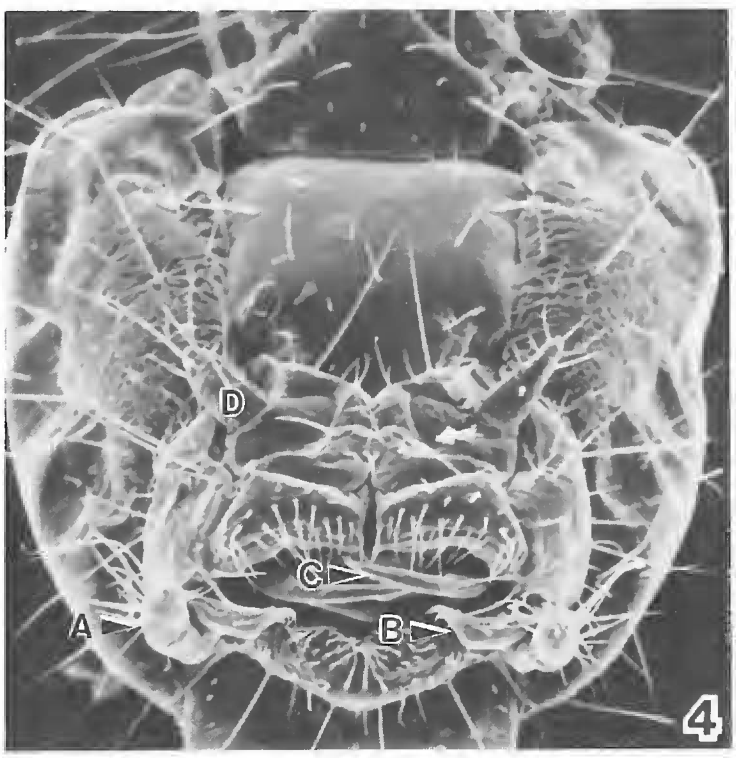


Figure 1a. Dorsal view of a *Metajapyx* specimen from Washington State. Head width was measured from the base of the diverging frontal sutures (A), head length from between the antennal scapes to the base of the coronal suture (B). Cerci were measured on the dorsal surface from the most distal point to the point of articulation with abdominal tergum 10. Figure 1b. Line drawing of the ventral surface of the head of a *Metajapyx* specimen. A = labial palp; B = admental plate; C = prementum; D = postmentum; E = submentum.







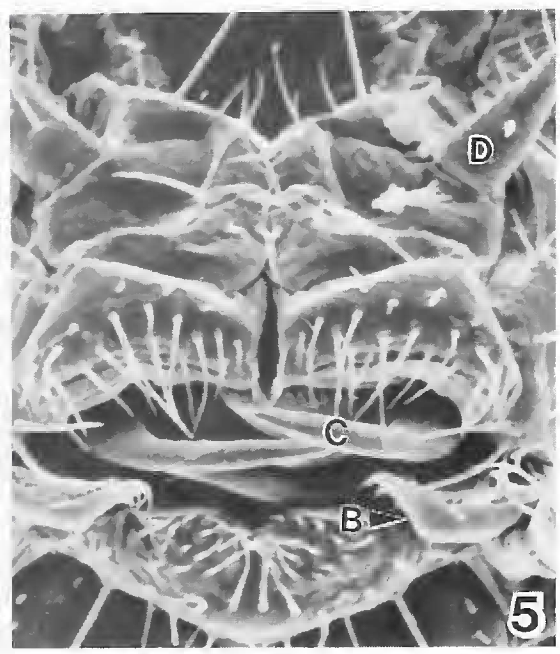


Figure 2. Rectangular-shaped head of a *Metajapyx* specimen without compound eyes or ocelli. Antennae are 26 segmented with trichobothria (A) on the 4th and 5th antennal segments. × 63. Figure 3. Ventral surface of a *Metajapyx* specimen head. Visible structures are labial palp (A), admental plate (B), prementum (C), postmentum (D) and submentum (E). × 208. Figure 4. Entognathous mouth parts of a *Metajapyx* specimen, ventral view. A = maxillary palp; B = galea; C = outer lamina of lacina; D = labial palp. × 167. Figure 5. Enlargement of mouth parts shown in Figure 3. × 280.

consist of an outer knife-like structure that is long, curved and heavily sclerotized (Fig. 8a) and an inner section subdivided into 5 pectins; the dorsal pectin with 5 distal teeth, the ventral pectins each with 20 teeth extending proximad to the base (Fig. 8c).

The order Diplura contains a few taxa which are thought to be carnivorous. For example, in central Europe japygids feed on collembola (Onychiuridae) and campodeids (Manton 1972). Two hours of observations of 20 *Metajapyx* specimens in the laboratory were made to record prey capturing behavior. These observations

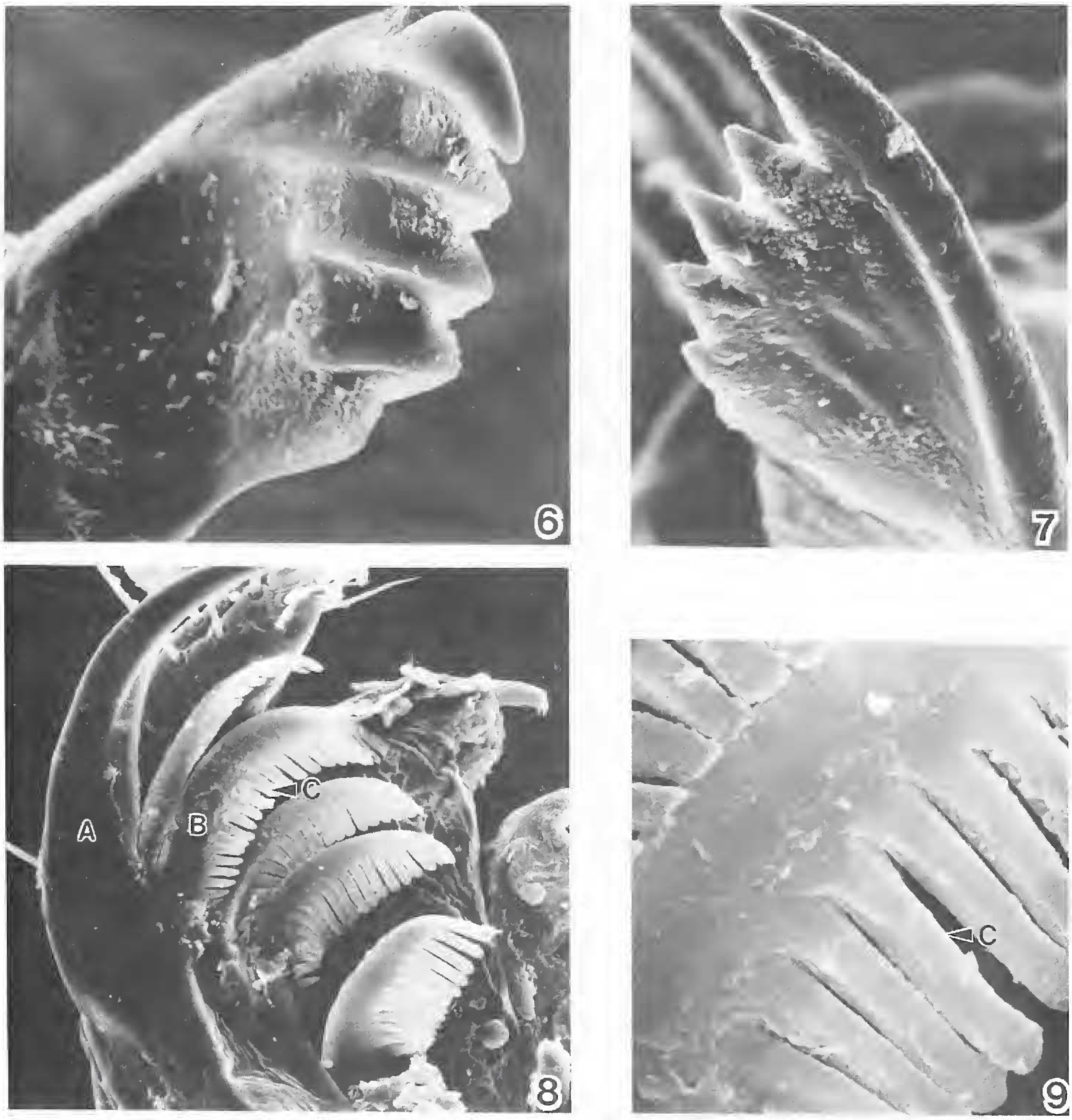


Figure 6. Inner surface of right mandible of a *Metajapyx* specimen showing 4 well-developed teeth. × 875. Figure 7. Outer surface of left mandible of a *Metajapyx* specimen with 5 teeth visible. × 1166. Figure 8. Left lacinia of maxilla of a *Metajapyx* specimen with 5 pectinate laminae visible on the mesal surface. A = outer lamina of lacinia; B = inner lamina of lacinia; C = pectin of inner lamina. × 470. Figure 9. Enlargement of pectinate laminae of Figure 7. × 2560.

failed to reveal a single individual capturing prey, even though collembola (Onychiuridae) were abundant. One individual was observed for 10 minutes scraping soil particles with extended mandibles. *Metajapyx* is probably a scavenger on dead arthropods, fungal mycelia, and organic debris. The highly modified maxillae indicate that *Metajapyx* may feed by filtering micro-flora and fauna through the pectinate laminae of the lacinae (Fig. 9c). Detailed examination of the mouth parts with SEM combined with laboratory observations support this hypothesis.

Conclusive determination of feeding habits of *Metajapyx* requires an analysis of gut contents. Individuals kept in a laboratory culture had brown digestive tracts, suggesting that soil was being filtered through the alimentary canal. Denis (1949) reviewed the feeding behavior of diplurans, especially the campodeids. Marten (1939) and Wygodzinsky (1941) noted animal fragments in the gut of *Campodea lankesteri* Silvestri, and they observed *C. lankesteri* attacking and feeding on sciarid larvae 5–7 mm long.

Valentine and Glorioso (1978) studied grooming behavior in *Metajapyx*. Their conclusions were that the complex lacinia with 5 pectinate laminae may function in antennal cleaning. Laboratory observations of the Washington *Metajapyx* specimens revealed frequent passage of the antennae through the mouth parts, as often as 10 times/min. Mouth parts were also used in grooming the body. Two individuals were observed using their mouth parts to clean body surfaces from the thorax to the cerci.

Cerci.—The family Japygidae is characterized by unisegmented, compact cerci which are strongly sclerotized and forcep-like. In *Metajapyx,* cerci, appendages of the 11th segment, are asymmetrical and armed with numerous sharp projections on the inner surface (Fig. 1a). Viewed dorsally, 2 rows of teeth are visible on the left arm (Fig. 10a). One row of teeth is visible on the right arm (Fig. 10b). Length [right cercus: 637.50 ± 32.89 μm ($n = 8$) and left cercus: 651.02 ± 28.84 μm ($n = 7$)] and shape were approximately equal on all examined specimens. Setae are present on both dorsal and ventral surfaces of the cerci, suggesting the forceps may be used in food and/or mate recognition.

Kosaroff (1935) reported that cerci hold prey that are then attacked by using the mouth parts. In *C. aquilonaris* cerci are adapted for grasping prey. SEM of the cerci of *C. aquilonaris* showed numerous small pits and scale-like bristles which may serve as mechanoreceptors (Nosek et al. 1974).

Abdominal Appendages.—Lateral styliform appendages were present on the sterna of segments 1 through 7 (Figs. 11b and 12b). Just medial to the styliform appendages of abdominal segment 1 were a pair of setose subcoxal organs occupying approximately $^2/_3$ the distance between the styli (Fig. 11a). Setae of the subcoxal organs (approximately 50/side) were arranged in a single row and were approximately $^1/_3$ the length of the abdominal styli. The function of the setose subcoxal organs is unknown. A median glandular structure sometimes protrudes between these structures (Smith and Bolton 1964), occupying $^1/_{10}$ the distance between the styli. In the 10 specimens examined from Washington this gland was never visible.

Paired eversible vesicles resembling those of Thysanura are found on abdominal segments 2–7 of Campodeidae and Anajapygidae, on sterna 2 and 3 of the Parajapygidae, and on sterna 1–7 in the Japygidae (Richards and Davis 1977). In *Campodea* the vesicles may function in water uptake (Drummond 1953). In *Metajapyx* sp. paired eversible vesicles were not seen.

Very setaceous papillae associated with the gonopore of a male *Metajapyx* were present between the 8th and 9th abdominal sterna (Figs. 12a and 13). Von Orelli (1956) demonstrated that male campodeids deposit spermatophores at random. The female locates the spermatophore and positions it within her gonopore. Sperm transfer has not been observed in the Japygidae; however, the structure of the papillae indicates that spermatophore deposition may not be a random process. The male may use sensory setae on the papillae to position the spermatophore either in the soil substrate or within the female gonopore.

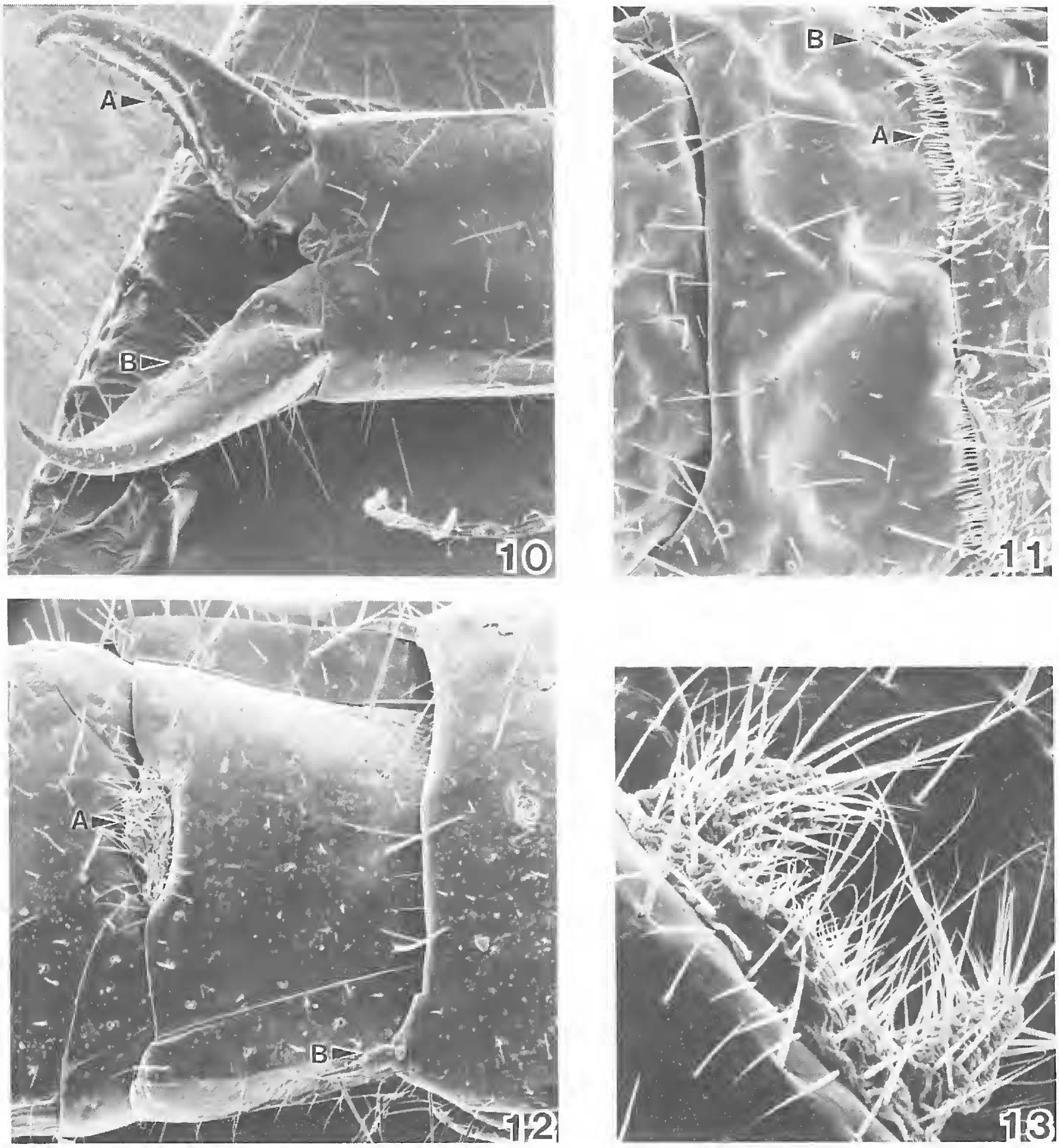


Figure 10. Forcep-like cerci of a *Metajapyx* specimen, dorsal view. A = denticles of left forcep; B = denticles of right forcep. × 62. Figure 11. Setose subcoxal organ (A) of a *Metajapyx* specimen between abdominal sterna 1 and 2. B = lateral styliform appendage. × 118. Figure 12. Reduced 9th abdominal sternum and setose genital papillae (A) of male *Metajapyx* specimen. Lateral styliform appendages (B) are visible on abdominal sternum 6. × 90. Figure 13. Enlargement of genital papillae of Figure 12. × 336.

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References

Chandler, L. 1957. The orders Protura and Diplura in Indiana. Proc. Indiana Acad. Sci. 66:112–114.

Denis, R. 1949. Sous-classe des Apterygotes: Anatomie, Biologie, Systematique. *In* Traite de Zoologie: Anatomie, Systematique, Biologie. Tome IX, Masson. Paris.

Denis, R. and J. Bitsch. 1973. Structure cephalique dans les ordres des insectes. *In* Traite de Zoologie: Anatomie, Systematique, Biologie. Tome VIII (I), Masson, Paris.

Drummond, F. H. 1953. The eversible vesicles of *Campodea* (Thysanura). Proc. R. Entomol. Soc. Lond., (A), 28: 145–148.

Fox, I. 1941. New or little known North American Japygidae (Thysanura). Can Entomol. 73:28–31.

Kosaroff, G. 1935. Beobachtungen über die Ernährung der Japygidae. Izvest. Carsk. Prirodonaue. Inst. 8:181–185.

Manton, S. M. 1972. The evolution of arthropod locomotory mechanisms. Part 10. Locomotory habits, morphology and evolution of the hexapod classes. Zool. J. Linn. Soc. 51:203–400.

Marten, W. 1939. Zur Kennthis von *Campodea.* Z. Morphol. Oekol. Tiere 36:40–88.

Matsuda, R. 1979. Morphologie du thorax et des appendices thoraciques des insectes. *In* Traite de Zoologie: Anatomie, Systematique, Biologie. Tome VIII (II), Masson, New York.

Nosek, J., M. Sixl, and H. Waltinger. 1974. Sensory hairs and function of antennae in *Japyx.* Pedobiologia 14:113–117.

Orelli, M. von. 1956. Untersuchungen zur postembryonalen Entwicklung von *Campodea* (Insecta, Apterygota), Verh. Naturforsch. Ges. Basel, 67:501–574.

Paelt, J. 1957. Diplura. Genera Insectorum 212:123 pp.

Richards, O. W. and R. G. Davis. 1977. Imm's General Textbook of Entomology. 10th Ed. Vol. 1. Structure, Physiology and Development. Wiley and Sons, NY. 418 pp.

Silvestri, F. 1933. Sulle appendici del capo degli "Japygidae" (Thysanura Entrotropha) e rispettivo confronto quelle dei Chilopodi, dei Diplopodi e dei Crostacei. Fifth Internat. Cong., Paris 1932, 2:329–343.

Silvestri, F. 1947. On some Japygidae in the Museum of Comparative Zoology. Psyche 54:209–229.

Smith, L. M. and C. L. Bolton. 1964. Japygidae of North America 9. The genus *Metajapyx.* J. Kans. Entomol. Soc. 37:126–138.

Valentine, B. D. and M. J. Glorioso. 1978. Grooming behavior in Diplura (Insecta: Apterygota). Psyche 85:191–200.

Wygodzinsky, P. W. 1941. Beiträge zur Kenntnis der Dipluren und Thysanuren der Schweiz. Denkschar. Schweiz. Naturforsch. Ges. 74:113–227.

Young, F. N. 1951. *Metajapyx subterraneus* (Packard) in Indiana (Aptera: Japygidae). Proc. Indiana Acad. Sci. 60:332–333.